The Transferability of Regional Climate Models to non-native domains at varying time-scales

Zav Kothavala, Colin Jones, Dominique Paquin, Burkhard Rockel, Ayrton Zadra & John Roads
Introduction

To determine that Regional Climate Models can realistically simulate the climate variability in all regions of the globe, we want to develop parameterizations that are evaluated against observations in all possible climates.

Regional atmospheric climate Models from different Continental Scale Experiments (CSE) were transferred from their “native domain” to other continents involved in the Inter-CSE Transferability Study (ICTS) - GEWEX sub-project.
The ICTS Regional Climate Modeling protocol aims to capitalise on the global coverage offered by CEOP observations to assess and improve the global transferability of RCMs.

Unmodified RCMs were run on a variety of domains around the globe.
Participating RCMs

RCA3    Rossby Centre (Sweden)
CLM     GKSS Research Centre (Germany)
RSM     Scripps Institution of Oceanography (USA)
RegCM3* Iowa State University (USA)
MM5#    Iowa State University (USA)
GEM-LAM RPN Environment Canada (Canada)
MRCC    Ouranos-UQAM, Montréal (Canada)

* Not all domains simulated;  # Computer hardware problems
MRCC characteristics

- Caya & Laprise, MWR (1999); version 4.1
- Fully elastic non-hydrostatic equations
- Uniform horizontal grid on a polar stereographic projection (approx 45 km resolution at center of grid)
- 29 vertical levels (top at 30 km ~10 hPa)
- 15 minute timestep - period: 2000/01/01 – 2004/11/30
- Solar constant 1367 kw/Wm²
- Transient GHG concentrations
- Deep & shallow convection (Bechtold-Kain-Fritsch)
- Simple super-saturation based large-scale condensation
- CLASS v2.7 land-surface scheme
- Boundary forcing every 6 hours with NCEP2 reanalyses
GEM-LAM characteristics

- Coté et al., MWR (1998); version 3.2.1
- Hydrostatic primitive equations
- Rotated grid on lat lon projection (0.5 degree horizontal resolution)
- 53 hybrid vertical levels (top at ~10 hPa)
- 30 minute timestep - period: 2000/01/01 – 2004/12/31
- Solar constant 1367 kw/Wm²
- Constant GHG concentrations
- Deep convection (Kain-Fritsch) & shallow convection
- Simple super-saturation based large-scale condensation
- ISBA land-surface scheme
- Boundary forcing every 6 hours with NCEP2 reanalyses
CEOP Reference sites

BALTEX (Europe)
• Lindenberg 52.2N 14.12E
• Cabauw 51.97N 4.93E

GAPP (North America)
• Bondville 40.01N 88.29W

MAGS (Alaska & Western Canada)
• Fort Peck 48.31N 105.1W
• BERMS 53.99N 105.12W
• Barrow AL 71.3N 156.62W

LBA (South America)
• Rondonia 10.08S 61.93W
• Manaus 2.61S 60.21W

GAME (Asia)
• NE Thailand 45.74N 106.26E
• Tibet plateau 31.37N 91.9E

MDB (Australia)
• ARM Manus 2.06S 147.43E
• Tumbarumba 35.6S 148.15E

Outline
An evaluation of surface variables at the annual, seasonal, and diurnal time-scales are presented.
Annual Time-scale: Simulations over native domains
(N. America & Europe)
Simulation for non-native domain
Barrow, Alaska: Radiation fluxes over the Arctic

SW down

SW up

LW down

LW up
Cabauw: Taylor Diagram (all RCMs, all variables)
Manaus: Taylor Diagram (Non-native domain, all RCMs)
Seasonal Time-scale: Simulations over native domains
Bondville: freq. distribution (Surface temperature)
Bondville: frequency distribution (Precipitation)

Bondville DJF 2002–2004 Daily total pcp (mm)

- **Obs**: 141
- **RCAI**: 255
- **MRCC**: 389
- **GBM**: 380
- **RSN**: 444
- **CLM**: 169

Bondville JJA 2002–2004 Daily total pcp (mm)

- **Obs**: 533
- **RCAI**: 570
- **MRCC**: 526
- **GBM**: 569
- **RSN**: 1194
- **CLM**: 1108
Seasonal Time-scale June-July-August: sites from all domains

1. Lindenberg
2. Cabauw
3. Bondville
4. Mongolia
5. Tibet
6. Inner_Mong
7. Himalayas
8. NE Thailand
9. Manaus
10. Tumbarumba
11. Barrow
Seasonal Time-scale June-July-August: sites from all domains

1. Lindenberg
2. Cabauw
3. Bondville
4. Mongolia
5. Tibet
6. Inner_Mong
7. Himalayas
8. NE Thailand
9. Manaus
10. Tumbarumba
11. Barrow
Manaus: Brazil - 2.61S 60.21W
JAS 2001 Non-native domain freq. distrib.: (Manaus: South America)
Diurnal Time-scale: native domain
(Bondville, USA 40.01N 88.29W)
Diurnal Time-scale June-July-August: (Manaus: 2.61S 60.21W)
Diurnal Time-scale:
Temperature (top-left)
Precipitation (top right)
Wind-speed (lower left)

RCA3 anomalies noticed in JJA only!
In the original ICTS runs the RCA3 model had a large warm bias in screen temperature during the dry season over South America.
Manaus: Precipitation & Sp. humidity
In the original RCA3 runs, the surface latent heat flux rapidly fell close to zero in the dry season, with a commensurate increase in the surface sensible flux. As a result of the shut down of surface evaporation, the surface soil layer warms rapidly leading to the large warm temperature bias seen earlier.

**Manaus: Surface Latent Heat Flux**

![Manaus: Surface Latent Heat Flux](image)

**Manaus: Surface Sensible Heat Flux**

![Manaus: Surface Sensible Heat Flux](image)

--- CEOP Observations

--- RCA3_original
Using the ECOCLIMAP surface physiography data-set and different atmospheric physics, the new RCA3 runs (RCAECO) show a much improved agreement of near-surface temperature with the CEOP observations over South America.

**Manaus: Screen temperature**

![Manaus Temperature Chart]

**Sanatrem: Screen temperature**

![Sanatrem Temperature Chart]

**CEOP Observations** ...... **RCA3_original** — **RCAECO** —
Summary

• The objective of the ICTS analyses is to evaluate the performance of Regional Climate Models over non-native domains at various time-scales through a rigorous comparison with field observations.
• Results to date reveal which RCM performs well (or inadequately) in different domains/climate regimes.
• Ongoing collaboration with individual modelling groups to ascertain reasons for variations and possible fixes.